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## PERFORMANCE OF SCAB RESISTANT POTATO VARIETIES IN WESTERN NEBRASKA


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(Accepted for publication March 2, 1951)


Common scab has long been a major problem with the potato crop in western Nebraska. Although relatively little scab occurs in some seasons, the tendency in recent years has been for it to be more prevalent and of a more severe nature in an increasing number of fields. Rotations and cultural practices, which formerly gave fairly satisfactory control, seem ineffective and scab resistant varieties now appear to provide the most satisfactory solution. Consequently, all obtainable varieties which have been reported to be scab resistant and which possess suitable characteristics for commercial production in Nebraska were included in outstate variety trials in 1948 and 1949.

In both years, Ontario, Menominee, Russet Sebago, Yampa and Progress were tested. Triumph was used as a check variety because it has been the standard variety of the area. Cayuga and Russet Rural were planted in small observation plots in some of the tests.

[1] Published with the approval of the Director as paper No. 523, Journal Series, Nebraska Agricultural Experiment Station.

## LOCATION AND CHARACTERISTICS OF TRIAL SITES

The trials were located on the substations in western Nebraska — the Box Butte (dryland) and Scotts Bluff (irrigated) Stations — and on privately owned dryland or irrigated farms selected because of their location in certain production areas, or because of soil characteristics or serious incidence of scab, as shown in table 1. The range in altitude of these locations varied from 3700 feet at Bayard to 5300 feet in Banner County.

The long time average temperature for the various sites ranges from 65° to 66.4° in June, 71.8° to 73.2° in July, 70.0° to 73.2° in August and 60.1° to 62.0° in September. In 1948, temperatures averaged slightly below normal for June and July, about average in August, and considerably higher in September (2.9 to 5.3 degrees). In 1949, June was slightly cooler than normal, July and August slightly warmer, and September 0.1 to 1.5 degrees cooler. Generally, the places of lower altitude had the higher temperatures.

The long time average rainfall at the various locations ranged from 2.69 to 3.97 inches in June, 1.5 to 2.37 in July, 1.62 to 2.51 in August and 1.11 to 1.39 in September. In 1948, June precipitation was considerably above the average, that of July and August was slightly below and of September slightly above the average. In 1949 it was slightly above average in June, considerably below average in July, normal in August and considerably above average in September. Usually only one-half to two-thirds of the summer rainfall was available for use by plants. Some of it feil so rapidly that the run-off was very graet — some in such small amounts that it did not penetrate to root depth.

Although the trials were on soil typical of the land being used for potato production in a locality, the results are not necessarily indicative of those that could be expected on all the soil classes of each locality. Most of the trials were on very fine sandy loam, but some were on silt loam or on loamy fine sand.

One pair of tests was located on land known to be severely infested with scab. This was in southern Sioux County north of the town of Morrill — in the area locally known as the "Dutch Flats." This was one of the first localities in western Nebraska to grow potatoes commercially, but during the last few years the acreage here has decreased from 4300 acres in 1937, to 2790 acres in 1942 and 890 acres in 1947.[1] The high percentage of scab in practically all fields in that locality has made potato growing unprofitable.

On the Experiment Station farms each variety used in the yield tests

[1] Eckstrom, Victor A: Marketing Nebraska-Eastern Wyoming Potatoes. Market quality of the crop and summary 1948-'49 season, USDA-P&MA, Fruit and Vegetable Branch, (Mimeographed August 1948.).

TABLE 1.—*Information concerning various test plot locations in western Nebraska.*

| Test Numbers 1948\|1949 | Location of Test Plats | | | Dates 1948 | | Dates 1949 | | Specific Aspects of Test or Location |
|---|---|---|---|---|---|---|---|---|
| | County | Place | Altitude | Plant. | Harv. | Plant. | Harv. | |
| **Irrigated Tests** | | | | | | | | |
| 1 and 12 | Scotts Bluff | Exp. Farm (Mitchell) | 4000 | 5/26 | 10/1 | 5/19 | 10/7 | |
| 2 " 13 | " | " " | " | 6/5 | 10/2 | 6/3 | 10/9 | Four planting dates, |
| 3 " 14 | " | " " | " | 6/15 | 10/4 | 6/16 | 10/9 | very fine sandy loam |
| 4 " 15 | " | " " | " | 6/25 | 10/18 | 6/30 | 10/9 | |
| 5 | " | Haig | 4120 | 6/4-6/21 | 10/13 | ..... | ..... | North slope, silt loam |
| 6 | " | Gering | 4130 | 6/1-6/21 | 10/9 | ..... | ..... | South slope of bluff, very fine sandy loam |
| 19 | " | " | 3800 | ..... | ..... | 5/8-6/18 | 10/6 | Flood plain, silt loam |
| 7 | " | Minatare | 3750 | 6/2-6/25 | 10/16 | ..... | ..... | very fine sandy loam, scab infestation medium |
| 8 and 16 | Sioux | Morrill | 4100 | 6/3-6/19 | 10/6 | 5/23-6/15 | 10/13 | Severe scab infestation, very fine sandy loam. |
| 9 | Scotts Bluff | Scottsbluff | 4100 | 6/3-6/19 | 9/29 | ..... | ..... | Loamy very fine sand |
| 10 " 17 | Morrill | Bayard | 3700 | 6/2-6/24 | 10/15 | 5/24-6/16 | 10/5 | Lower altitude of N.P. Valley, very fine sandy loam |
| 11 " 18 | Kimball | Kimball | 4700 | 5/31-6/27 | 10/11 | 5/25-6/20 | 10/12 | High altitude, Lodge Pole Valley, very fine sandy loam |
| 20 | Sioux | Henry | 4200 | 5/23-6/15 | 10/10 | ..... | ..... | Higher altitude of N.P. Valley, very fine sandy loam |
| **Dryland Tests** | | | | | | | | |
| 21 and 27 | Box Butte | Exp. Farm (Alliance) | 4000 | 5/26 | 10/19 | 5/20 | 10/3 | |
| 22 " 28 | " | " " | " | 6/7 | 10/19 | 6/2 | 10/3 | Four planting dates, |
| 23 " 29 | " | " " | " | 6/17 | 10/19 | 6/17 | 10/3 | very fine sandy loam. |
| 24 " 30 | " | " " | " | 6/28 | 10/15 | 7/1 | 10/3 | |
| 25 " 31 | Sheridan | Gordon | 3850 | 6/4-6/29 | 10/21 | 5/26-6/17 | 10/15 | Most northern and lowest altitude dryland area, very fine sandy loam. |
| 26 " 32 | Banner | Bull Canon Ranch | 5300 | 6/1-6/26 | 10/4 | 5/24-6/20 | 10/11 | Highest altitude in Nebraska, very fine sandy loam |

was grown in randomized plots (4 rows of 12 hills each in 1948 and 4 rows of 20 hills in 1949). The varieties grown merely for observation were planted in single rows. The off-station plots had 4 rows of 12 hills each in 1948 and 1 row of 30 hills each in 1949. Most of the off-station plots were located in growers' fields where they received the same treatment as the commercial potatoes, but in a few places they were in isolated fields of other crops. Psyllids and fleabeetles were controlled in all plots by spraying or dusting several times with DDT.

In order to determine the most suitable planting dates in Nebraska for these new varieties and to increase the probability of having each variety under conditions favorable for scab infection, complete plots were planted on four different planting dates on the Experiment Station farms. The first planting was made in the latter part of May, the others at 10-day intervals in 1948 and 14-day intervals in 1949. In the off-station plots the late varieties, Ontario, Menominee, Cayuga, and Russet Sebago, were planted the latter part of May or first part of June and the early or mid-season varieties, Yampa, Triumph, and Progress, were planted at the normal planting time in the area; that is, June 15 to 29.

All of the plots were harvested in early October. Tubers were graded to determine percentages of US#1-A size grade and of those failing to meet that grade because of scab, roughness, sun greening, cuts, rot, harvest cracking or small size. In 1949 the scabby tubers were further graded into three classes: mild, medium and severe. The mild class included tubers with very light surface or not more than 1 or 2 small pits. These were generally considered acceptable in a US#1 grade if the amount of infected tuber did not exceed the tolerances of that grade. The medium class tubers showed 50 per cent light surface scab or not more than 5 or 6 small to medium sized pits. In the severe class the tubers were so scabby that they did not meet the requirements of U.S. grade 2.

## RESULTS

### OCCURRENCE OF SCAB

The total amount of scabby tubers with Ontario, Cayuga or Menominee averaged 3.1 per cent or less in 20 irrigated tests and 0.4 per cent or less in 11 dryland tests (table 2). With three other varieties, Yampa, Progress and Russet Sebago ,scab was more prevalent. However, with these three varieties scab was of little consequence except in fields where it was very serious with highly susceptible varieties such as Triumph. In some of these fields the percentage of scabby potatoes was relatively high, but even then, these three varieties were more desirable than Triumph because scab was of a milder type and covered less area on the infected tubers (Figs. 1 and 2).

TABLE 2.—*Per cent of scabby potatoes in western Nebraska potato variety trials in two years. (calculated as percentages of total yields).*

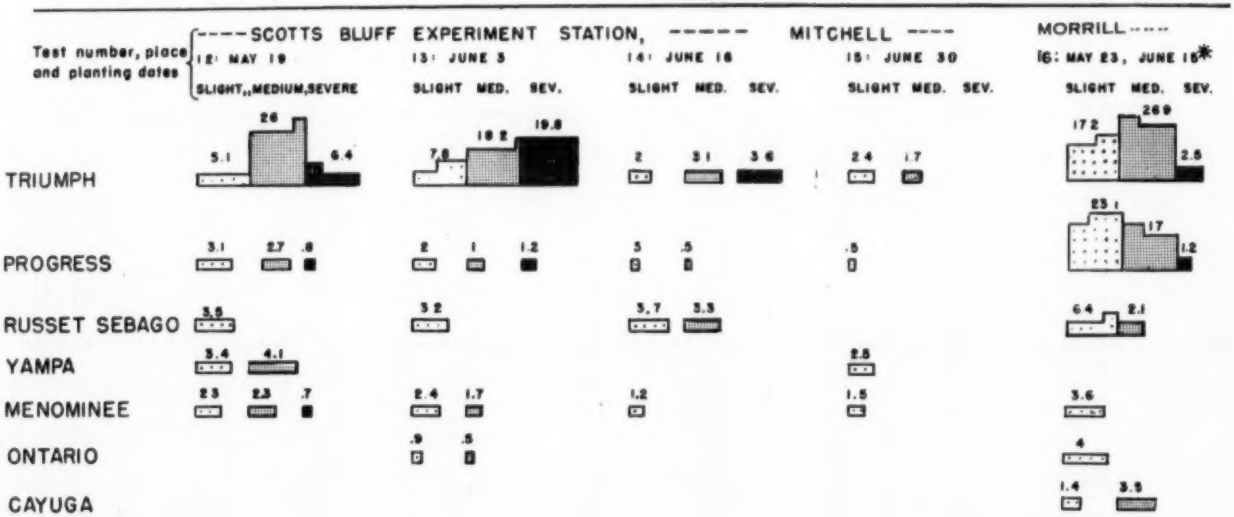
| | Test No. | Location | Planting Dates | Triumph | Progress | Yampa | Ontario | Menominee | Russet Sebago | Cayuga |
|---|---|---|---|---|---|---|---|---|---|---|
| Irrigated Plats 1948 | 1 | Mitchell[2] | 5/26 | 8.7 | 0.8 | 2.0 | 0.0 | 0.0 | 0.6 | |
| | 2 | Mitchell | 6/5 | 27.8 | 4.1 | 1.9 | 0.0 | 1.0 | 0.5 | |
| | 3 | Mitchell | 6/15 | 18.2 | 0.6 | 1.3 | 0.0 | 2.6 | 0.0 | |
| | 4 | Mitchell | 6/25 | 89.3 | 5.1 | 0.0 | 0.0 | 1.7 | 0.0 | |
| | 5 | Haig | 6/4-6/21[1] | 93.4 | 20.9 | 11.8 | 3.4 | 8.9 | 71.3 | |
| | 6 | Gering | 6/1-6/21[1] | 6.1 | 4.5 | 0.0 | 0.0 | 0.0 | 3.3 | |
| | 7 | Minatare | 6/2-6/25[1] | 90.5 | 5.1 | 4.5 | 0.0 | 1.6 | 2.6 | |
| | 8 | Morrill | 6/3-6/19[1] | 84.7 | 53.1 | 37.0 | 2.7 | 3.9 | 78.9 | |
| | 9 | Scottsbluff | 6/3-6/19[1] | 0.6 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 10 | Bayard | 6/2-6/24[1] | 86.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 11 | Kimball | 5/31-6/27[1] | 55.4 | 5.8 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Irrigated Plats 1949 | 12 | Mitchell | 5/19 | 37.5 | 6.5 | 7.4 | 0.0 | 5.3 | 3.5 | 0.0 |
| | 13 | Mitchell | 6/3 | 45.8 | 4.4 | 0.0 | 1.4 | 4.1 | 3.2 | 0.0 |
| | 14 | Mitchell | 6/16 | 8.7 | 1.1 | 0.0 | 0.0 | 1.2 | 7.0 | 0.0 |
| | 15 | Mitchell | 6/30 | 4.1 | 0.5 | 2.5 | 0.0 | 1.5 | 8.4 | 0.0 |
| | 16 | Morrill | 5/23-6/15[1] | 46.6 | 41.3 | 0.0 | 4.0 | 3.6 | 8.6 | 4.9 |
| | 17 | Bayard | 5/24-6/16[1] | 27.2 | 10.4 | 0.0 | 6.6 | 5.3 | 22.4 | 0.0 |
| | 18 | Kimball | 5/25-6/20[1] | 41.7 | 15.2 | 12.1 | 0.0 | 2.6 | 9.6 | 0.0 |
| | 19 | Gering | 5/18-6/18[1] | 39.4 | 18.6 | 19.3 | 0.8 | 4.1 | 9.7 | 0.0 |
| | 20 | Henry | 5/25-6/15[1] | 87.5 | 57.7 | 47.4 | 7.9 | 14.7 | 34.3 | 10.5 |
| | | Mean of 20 plots | | 45.0 | 12.8 | 7.4 | 1.3 | 3.1 | 13.2 | |
| | | Number of tests superior to Progress | | 0 | ..... | 14 | 19 | 16 | 14 | |
| Dryland Plats 1948 | 21 | Alliance[3] | 5/26 | 4.8 | 0.8 | 0.0 | 0.0 | 0.0 | 0.4 | |
| | 22 | Alliance | 6/7 | 0.8 | 3.8 | 4.9 | 0.0 | 1.3 | 0.6 | |
| | 23 | Alliance | 6/17 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 24 | Alliance | 6/28 | 8.4 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 25 | Gordon | 6/4-6/29[1] | 2.7 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 26 | Banner Co. | 6/1-6/26[1] | 14.9 | 8.2 | 0.0 | 0.0 | 0.0 | 2.7 | |
| Dryland Plats 1949 | 27 | Alliance | 5/20 | 42.0 | 10.3 | 9.9 | 0.7 | 0.7 | 6.5 | 1.4 |
| | 28 | Alliance | 6/2 | 29.3 | 7.4 | 1.8 | 0.9 | 2.4 | 4.7 | 0.0 |
| | 29 | Alliance | 6/17 | 13.1 | 13.7 | 2.4 | 0.0 | 0.5 | 0.0 | 1.4 |
| | 30 | Alliance | 7/1 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 31 | Gordon | 5/26-6/17[1] | 2.2 | 0.0 | 2.4 | ..... | ..... | ..... | ..... |
| | 32 | Banner Co. | 5/24-6/20[1] | 5.4 | 1.0 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | Mean of 11 plots | | 11.2 | 4.2 | 2.0 | 0.1 | 0.4 | 1.4 | |
| | | Number of tests superior to Progress | | 2 | ..... | 7 | 9 | 9 | 9 | |

[1] Triumph, Progress and Yampa planted last date, Ontario, Menominee, Russet Sebago and Cayuga planted first date.

[2] Mitchell is the post office designation of the Scotts Bluff Substation.

[3] Alliance designates the Box Butte Experiment Farm.

## SCABBY POTATOES - "A" SIZE AS PER CENT OF TOTAL WEIGHT PRODUCED
### IRRIGATED 1949



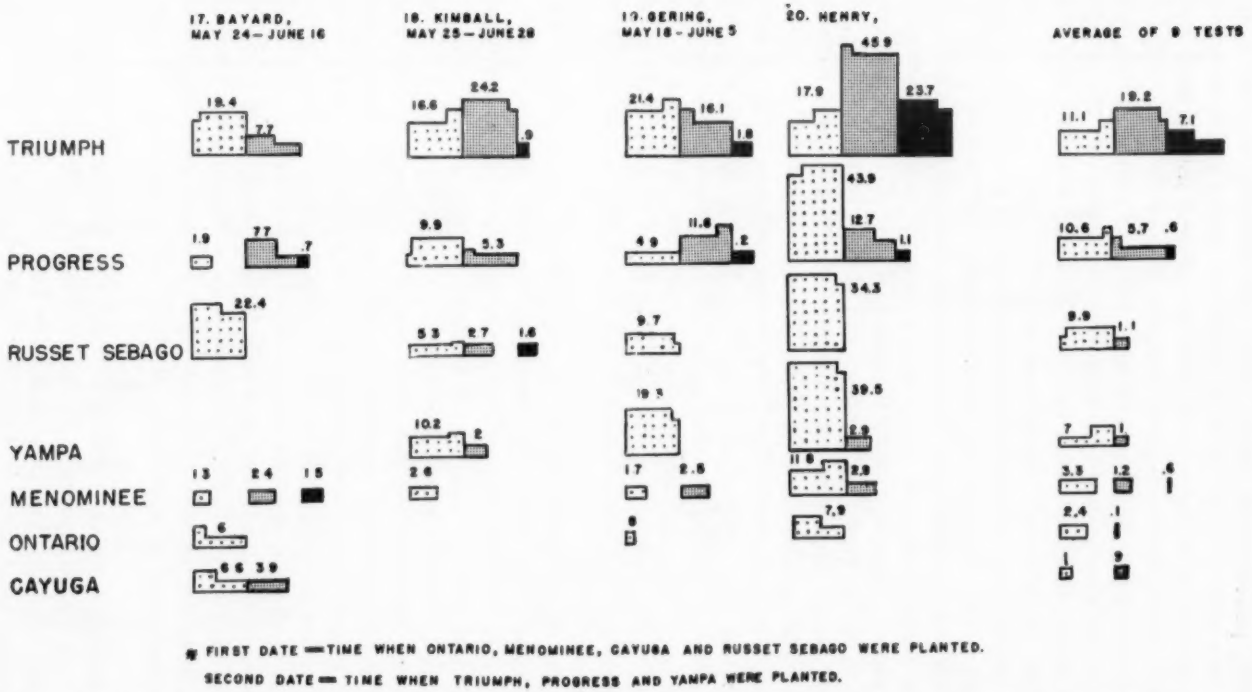



Fig. 1. Incidence of scabby tubers of three classes of severity shown as percentages of total weights produced by each of seven varieties grown in 9 irrigated plots in 1949 and the means of these plots. Classes of scab: slight—lightest shading (at left); medium—intermediate shading; severe—solid black (at right). The amount of each class of scab is shown graphically — by having the areas in the diagrams represent the percentages indicated in figures immediately above those portions of the graphs.

The mean percentage of scabby tubers with Progress was less than one-third that with Triumph, the total percentage having also been less in 30 of the 32 tests. Furthermore, the scab lesions were usually small and shallow and therefore less serious on Progress than on Triumph (Figs. 1 and 2) where they were large and frequently pitted. In most plots Progress and Yampa had approximately the same amount of scab, but where scab was very severe Progress tubers generally revealed more scab than did Yampa. Both varieties had less scab than Russet Sebago.

Russet Rural, which is being grown commercially in one Nebraska area where scab is very common, was planted only in observational rows in a few of the tests in 1949. The data for this variety are not included in any of the tables. It showed more scab than any of the above-mentioned varieties except Triumph. Usually the scab was only of mild or medium type, but in one test (test 12) it revealed 12.8 per cent severe scab.

The type and incidence of scab was also influenced by the season, planting date, and conditions within the plot. The following environmental conditions appeared to have pertinence: Plot 9 was located on loamy very fine sand soil where scab very rarely or never occurred. In plot 6, where little scab occurred, the soil around the developing tubers was never wet because the ridges were very high and ditches were cut deep. The land in this plot sloped to the south so that this was probably the warmest of all plots. Plots 8 and 16 were chosen because scab had been very serious on those fields in recent years.

Because of experimental and practical experience, planting after mid-June has become a standard procedure in western Nebraska to reduce the amount of scab. In three series of tests involving successive planting dates, there was less scab with almost all varieties as planting was delayed. However, in 1948 in these and other plots, and in commercial fields, scab was relatively more prevalent than usual with later plantings. This general condition and the abnormal situations surrounding the 1948 planting-time series at Mitchell may have been responsible for the reversal of the customary trend in scab prevalence. With the early planting (plot 1) irrigation was inadequate, resulting in early maturity so that by early September, when conditions became favorable for scab infection and growth, the tubers of the early varieties had ceased to grow. With the last planting (plot 4), irrigation inadvertently began before the rows were ditched and the consequent flooding packed the soil around the young tubers in early August.

Late plantings were more effective in lowering the scab content with Progress and Yampa than with Triumph. Sometimes there was little or no scab with varieties that were planted on June 24 or later. However, when plantings were made in mid-June, scab frequently occurred to a

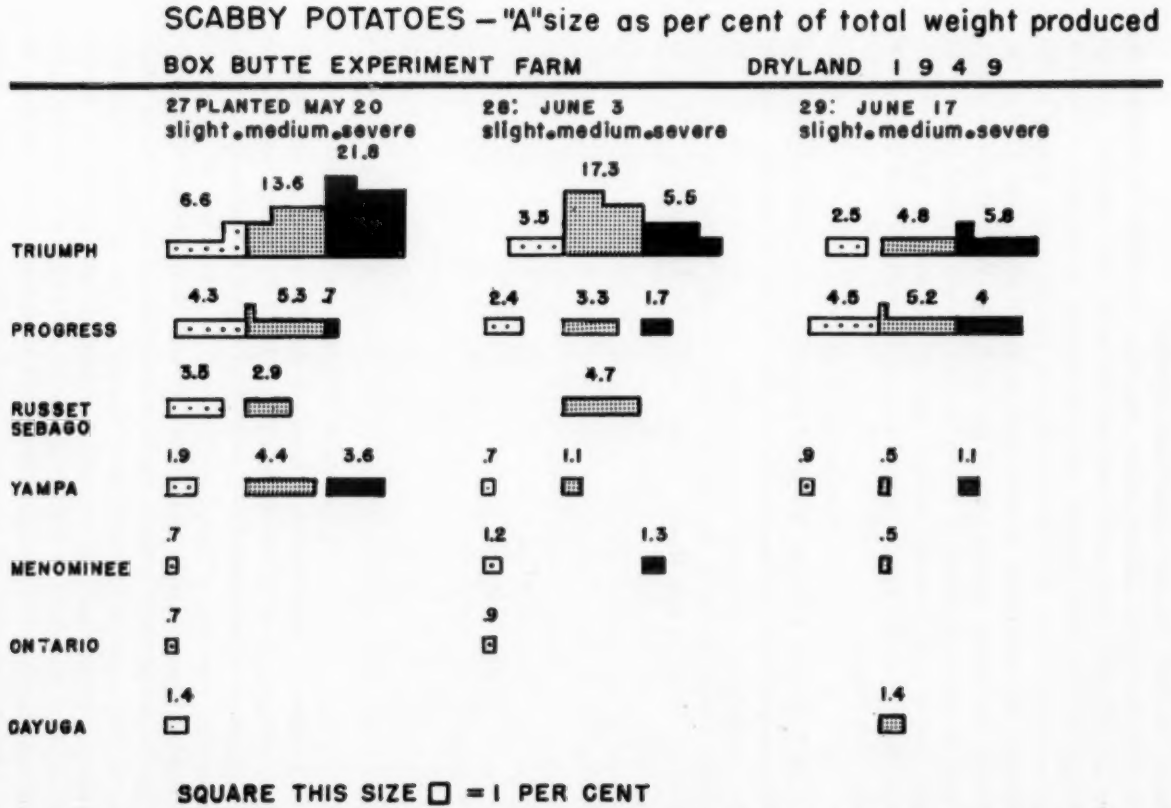



Fig. 2. Incidence of scabby tubers of three classes of severity shown as percentages of total weights produced by each of seven varieties with three planting dates on dryland at the Box Butte Experiment Farm in 1949. (For explanation of graphs see legend of figure 1).

serious extent with Progress and to only a slightly lesser extent with Yampa, but both had much less than Triumph.

In 1949 the scab on Ontario tubers was all of the mildest type except in one plot where a very small amount was rated with medium severity (Figs. 1 and 2). With Cayuga, scab was usually of the mild or medium type — never severe. With Menominee and Yampa, it was usually of the mild type, but occasionally it had a small amount of severe scab. Most of the infection on Russet Sebago was of the mild type. With Progress, under irrigation, about two-thirds of the scabby tubers were classified in the mild class; almost a third in the medium, and little or none in the severe. In the dryland tests the scabby tubers were more nearly divided among the three scab classes.

### YIELDS PER ACRE

With irrigation Triumph produced the highest total average yield with 398 bushels per acre, followed by Yampa with 376; Progress, 340; Ontario, 324; Menominee, 318; and Russet Sebago, 277 bushels (Table 3). On dryland Yampa produced the highest yields — 236 bushels per acre, followed by Progress and Russet Sebago with 206; Menominee, 204; Ontario, 192; and Triumph, 179 bushels.

Three of the varieties yielded about the same amount of US#1-A size grade with irrigation: Yampa, 217 bushels; Menominee, 213; and Ontario, 205; whereas, Russet Sebago produced 180; Progress, 172; and Triumph, 121 bushels. On dryland all these scab-resistant varieties produced greater yields of US#1 grade and greater total yields than did the Triumph. Yampa, with 178 bushels per acre, gave the highest yield of US#1 grade on dryland, followed by Russet Sebago with 148; Progress, 135; Menominee, 119; Ontario, 110; and Triumph, 109 bushels. The yields of US#1 grade tubers in the various tests in both years are reported graphically in figure 3.

### QUALITY OF TUBERS

The relative over-all quality of tubers of the different varieties is shown by the percentages of US#1-A size tubers (Table 3). Tubers from Yampa had shallow eyes and sometimes presented an attractive market appearance. Frequently, however, a high percentage of potatoes were of low grade because of growth cracks, sun green, oversize or roughness. The larger tubers were frequently hollow. As these defects were less prevalent when the potatoes were grown on dryland, Yampa may be more dependable for production there than with irrigation. Menominee and Ontario frequently did not have an attractive market appearance because of immaturity and numerous sun green or rough tubers, and because of great variation in size. Ontario possessed the peculiar habit of producing tubers in a chain-like manner on the stolons, and when harvested, these chains had to be

TABLE 3.—*Average yields per acre during two years with 19 irrigated and 10 dryland tests.*[1]

| Variety | Mean US No. 1-A Size | | Mean Total Yield | | Mean Per cent US No. 1-A Size | |
|---|---|---|---|---|---|---|
| | Irrigated | Dryland | Irrigated | Dryland | Irrigated | Dryland |
| | Bu. | Bu. | Bu. | Bu. | | |
| Triumph | 121 | 109 | 398 | 179 | 32.6 | 59.7 |
| Progress | 172 | 135 | 340 | 206 | 53.5 | 62.4 |
| Russet Sebago | 180 | 148 | 277 | 206 | 59.2 | 69.5 |
| Yampa | 217 | 178 | 376 | 236 | 59.3 | 72.8 |
| Menominee | 213 | 119 | 318 | 204 | 65.8 | 56.9 |
| Ontario | 205 | 110 | 324 | 192 | 61.3 | 52.6 |

[1] The data for tests 15 and 30 were omitted in deriving means because the stands in these plats were not only too poor, but also too irregular for comparative purposes.

broken up. Both of these varieties frequently produced an abundance of small tubers on dryland. Russet Sebago tubers were russeted and fairly attractive, but sometimes they were immature and had a mottled appearance because of variations in russeting. Russet Sebago did not produce so many rough tubers as the other late varieties. Menominee and Cayuga crops were very acceptable in some of the dryland plots.

Progress tubers presented an attractive market appearance, having a brighter, slightly darker red skin than Triumph. Where irrigation was irregular, growth cracks were numerous. Because of a propensity toward heavy setting, Progress commonly produced more small potatoes than the other varieties. It never produced any oversize tubers and practically none of the tubers cracked at harvest time. These small tubers are not as much of a liability with this variety as might be the case with others. They are in great demand for seed purposes because the poor wound healing characteristic of Progress tubers frequently is responsible for poor stands when cut seed pieces are planted. The percentage of US#1 potatoes was lowest with Triumph not only because of scab but also because of harvest damage.

The specific gravity averages of Yampa, Ontario, Menominee, Russet Sebago and Cayuga tubers were higher than those of Progress and Triumph (Table 4). In 1949 specific gravity averages were very high on dryland and low with irrigation. With the irrigated plots the 1948 averages were much higher than those of 1949, but in the dryland plots they were lower. The dry, cool September weather of 1949 contributed much to the high specific gravity of the tubers of the late varieties grown on dryland that year. In 1948, the higher-than-average September temperature, accompanied by

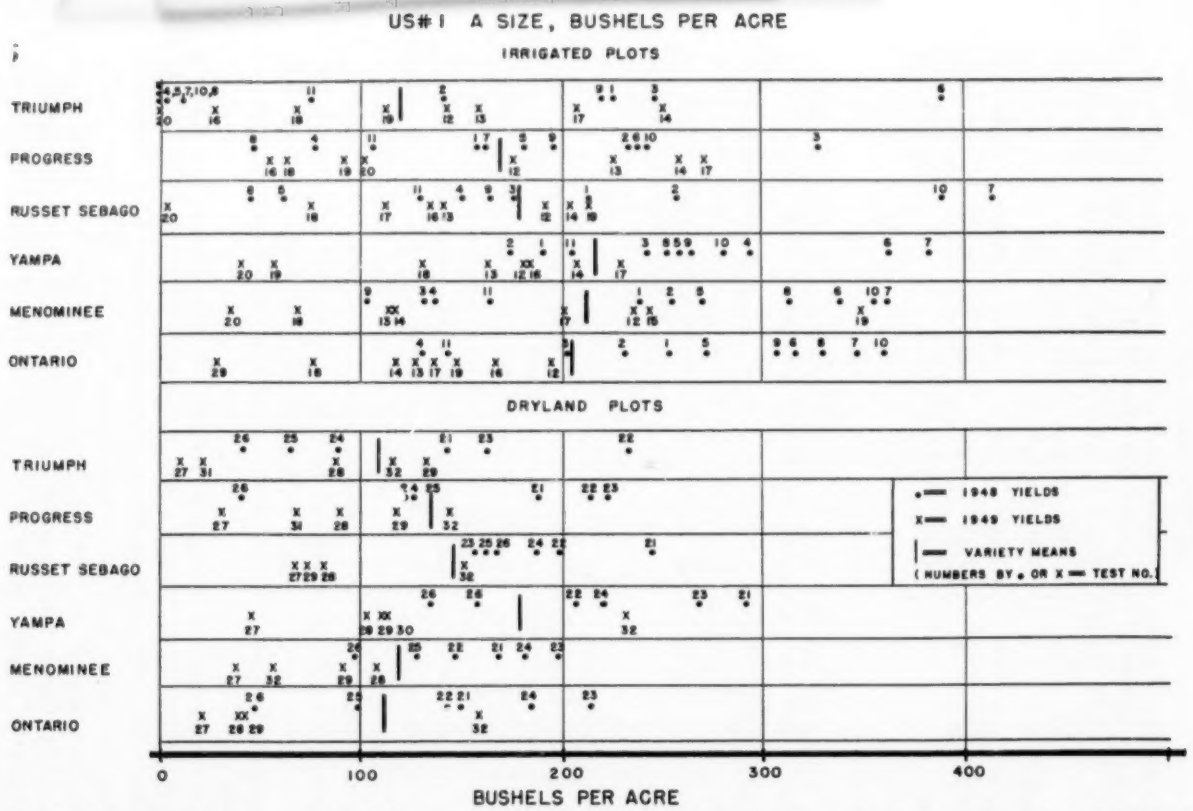



Fig. 3. Diagrammatic representation of the per acre yields of US#1 grade potatoes produced by each of 5 scab-resistant varieties grown in comparison with Triumph in each test in 1948 and 1949. The number by each value is that of the tests listed in table 1 and used to identify it throughout the article.

many very bright days, is considered the reason for the high specific gravity of the irrigated potatoes. On dryland, however, the combination of high temperature and a late summer soil moisture supply that was inadequate to maintain the previously developed large vines, was unfavorable for developing high carbohydrate content in the new tubers and consequently, their average specific gravity was lower than that of the 1948 irrigated or the 1949 dryland potatoes. In 1949 the moister, slightly cooler weather was much more conducive to much higher specific gravity on dryland than with irrigation.

TABLE 4.—*Mean specific gravity of tubers produced by mid-June planting in Scottsbluff and Alliance tests.*

| Variety | 1948 | | 1949 | | Mean All Tests |
|---|---|---|---|---|---|
| | Scottsbluff Irrigated | Alliance Dry land | Scottsbluff Irrigated | Alliance Dry land | |
| Triumph | 79.7[1] | 71.8 | 74.1 | 79.8 | 76.4 |
| Progress | 82.3 | 82.2 | 67.4 | 86.1 | 79.5 |
| Yampa | 83.0 | 87.8 | 72.1 | 99.1 | 85.5 |
| Ontario | 89.0 | 81.7 | 68.5 | 89.1 | 82.1 |
| Menominee | 87.4 | 86.6 | 66.6 | 94.0 | 83.7 |
| Russet Sebago | 91.0 | 82.0 | 74.5 | 91.9 | 84.9 |
| Cayuga | ..... | ..... | 89.9 | 99.5 | ..... |

[1] For convenience, decimal point is moved three places to right and 1.0 is omitted in each mean for specific gravity values.

## SUMMARY

1. Three late varieties, Ontario, Menominee and Cayuga, produced fewer scabby potatoes than any other of the commercial varieties tested during two years in a number of dryland and irrigated tests in western Nebraska. Because of grade inferiorities, due to rough and immature tubers, they are of promise for commercial production on only a limited number of irrigated farms where scab is usually very prevalent. On dryland the same defects occurred, but the yields of US#1-A size potatoes averaged higher than with the commonly grown Triumph.
2. Scab was more prevalent with Yampa and Russet Sebago than with the previously mentioned varieties. However, both appeared of dubious commercial value for irrigation — Yampa, because of hollow heart, growth cracks and sun-greened tubers and Russet Sebago because of immaturity ,one aspect of which was spotted russeting. On dryland Yampa tubers were of reasonably good quality with the average

production of U.S. # 1 tubers being greater than with any of the other varieties, but Russet Sebago was least productive.

3. Progress appeared to be the most desirable of the varieties in this test for western Nebraska, because the tubers possessed a red skin color with a relatively low incidence of mild types of scab, were free from harvest cracks, and made a pleasing market appearance with good table quality. In fields where scab was very severe Progress, at times, showed less scab than Russet Sebago.
4. Triumph produced a higher percentage of scabby tubers with more scab of severe types than any of the varieties in these tests.
5. The average specific gravity of tubers was higher with all these varieties than with Triumph.

## EFFECT OF APHID CONTROL ON THE SPREAD OF LEAFROLL IN POTATOES[1]

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Of the two species of aphids that attack potatoes in the Yakima Valley of Washington, the green peach aphid (*Myzus persicae* (*Sulz.*)) is the most abundant and also the most effective vector of the leafroll virus. Populations of the potato aphid (*Macrosiphum solanifolii* (Ashm.)) remain low and relatively constant throughout the season, rarely exceeding 5 per cent of the total aphid population. Leafroll has lowered yields and quality of potatoes at Yakima for many years. The greatest loss occurs in the Netted Gem (Russet Burbank) variety, where leafroll infection usually is accompanied by severe net necrosis in the tubers.

Insecticide tests conducted prior to 1949 indicated that 4 or 5 applications of 5 per cent DDT dust during the first 60 to 70 days of growth of the potato plants were sufficient to keep the seasonal populations of the green

[1] A cooperative study conducted by the Bureau of Entomology and Plant Quarantine, the Washington Agricultural Experiment Stations, and the Washington State Department of Agriculture.

peach aphid at levels of 4 or 5 aphids per plant. Although this control was adequate from the standpoint of preventing direct damage from the aphids, it was not effective in preventing the extensive spread of leafroll. The 1949 tests, therefore, were conducted to determine whether aphid control could be improved and whether measurable differences in leafroll spread could be obtained at the various levels of aphid population resulting from insecticide treatments.

## Methods and Equipment

Trials were conducted in one early- and one late-crop field of Netted Gem potatoes near Yakima in 1949. The insecticide dusts were applied with an 8-nozzle, 4-row power duster mounted on a tractor. Two nozzles were directed on each row, and a 7-foot canvas drape was attached to the duster boom. The duster was powered by a 6-horsepower gasoline engine and had an air-discharge velocity at each nozzle of 34 miles per hour. The plots were 8 rows wide and several hundred feet long. Treatments were arranged in randomized blocks replicated 6 times in the early-crop field (experiments 1 and 2) and 8 times in the late-crop field (experiment 3).

Eight laboratory-mixed dusts and two proprietary dusts were tested (table 1). One of the proprietary products contained 4 per cent of DDT and 80 per cent of sulfur, fused and reground. The other contained 5 per cent of DDT, 12.1 per cent of fused bentonite-sulfur, and sufficient dusting sulfur to bring the total sulfur content to 75 per cent. Pyrophyllite was used as the diluent in dusts mixed at the laboratory. A non-volatile oil, chiefly di- and tri-methylnaphthalenes, was added to two DDT dusts. The parathion dusts were prepared from a wettable powder containing 15 or 25 per cent of parathion. The sodium fluoaluminate dusts were prepared from commercial cryolite containing 90 per cent of sodium fluoaluminate. They were used for the control of the tuber flea beetle and the Colorado potato beetle and to serve as treated checks for the aphidicides.

An attempt was made to apply the dusts at the rate of 25 pounds per acre, but some plots received as little as 23 pounds. All plots were dusted four times, the first application being made when three-fourths of the plants were through the ground and the succeeding applications at 10- to 12-day intervals, except when treatments were delayed because of conflicts with growers' irrigation schedules. More applications could not be made with the duster, because rank vine growth closed the space between the rows.

The plots were sampled for aphids about 7 days after each dusting, and thereafter at 2-week intervals until harvest or frost. At each sampling 50 plants were located at random on the middle row of each plot. Counts were made on one random compound leaf from the bottom half of each

TABLE 1.—*Effectiveness of various insecticide dusts in controlling aphids and preventing spread of leafroll on early-crop potatoes in 1949*

| Insecticide | Green Peach Aphids | | Potato Aphids | | Incidence of Leafroll | |
|---|---|---|---|---|---|---|
| | Winged | Wingless | Winged | Wingless | Net Necrosis | Plant Test in 1950 |
| | Number | Number | Number | Number | Per cent | Per cent |
| | | | Experiment 1 | | | |
| DDT: | | | | | | |
| 5 per cent | 26 | 697 | 2 | 70 | 0.3 | 5.8 |
| 4 per cent plus sulfur 80 per cent | 25 | 361 | 4 | 96 | 0.3 | 3.3 |
| 5 per cent plus sulfur 75 per cent | 18 | 401 | 2 | 103 | 0.3 | 5.3 |
| Sodium fluoaluminate: | | | | | | |
| 33.3 per cent | 156 | 13,593 | 6 | 108 | 1.3 | 23.1 |
| 33.3 per cent plus parathion 0.5 per cent | 18 | 839 | 2 | 56 | 1.7 | 7.5 |
| Difference required for significance (P=5 per cent) | 51 | 3,452 | [1] | [1] | [1] | 8.1 |
| | | | Experiment 2 | | | |
| DDT: | | | | | | |
| 5 per cent | 52 | 883 | 2 | 30 | 1.0 | 4.2 |
| 5 per cent plus oil 2 per cent | 40 | 1,016 | 1 | 31 | 1.0 | 3.3 |
| 3 per cent plus oil 2 per cent | 67 | 1,165 | 4 | 25 | 0.7 | 3.3 |
| Parathion: | | | | | | |
| 0.5 per cent | 47 | 2,029 | 1 | 36 | 2.3 | 4.7 |
| 0.5 per cent plus DDT 5 per cent | 40 | 999 | 1 | 33 | 1.0 | 3.6 |
| 1 per cent | 57 | 1,469 | 1 | 24 | 1.3 | 4.2 |
| Difference required for significance (P=5 per cent) | [1] | 563 | [1] | [1] | [1] | [1] |

[1] Not significant by the *F* test.

plant. Ten counts were made between May 20 and August 24 in experiment 1; 9 counts between May 30 and August 24 in experiment 2; and 6 counts between August 1 and October 10 in experiment 3. A total of 3,000 compound leaves were examined in experiment 1; 2,700, in experiment 2; and 2,400, in experiment 3.

The percentage of plants affected by leafroll was determined by the phloroglucinol test (Klostermeyer 1950). For this purpose 100 stems were taken from separate plants in the center row of each plot. These plants were located in groups of 10 spaced at 20-foot intervals.

At harvest time 50 marketable-size potatoes were collected from the 2 middle rows of each plot. After 1 or 2 weeks of storage the potatoes were examined and the number having net necrosis was recorded. From each plot 450 potatoes weighing 1 to 3 ounces were collected and planted at the Irrigation Experiment Station at Prosser, Washington, during the first week of April 1950. In plots from experiments 1 and 2 all plants were examined on June 20 (table 1). Because of the higher incidence of leafroll in experiment 3, only 100 plants from each plot were examined for leafroll. Counts were made on July 3 (table 2).

Tuber samples taken from 2 plots in experiments 1 and 2 and from 11 plots in experiment 3 were lost during the winter because of rotting. Values for the missing plots in experiments 1 and 2 were computed according to Yates' formula and used in statistical analysis of the data. Owing to the large number of missing samples in experiment 3, the values for missing plots were not calculated. Instead, the data were analyzed by the analysis-of-variance method for unequal subsample numbers. The computed average number of replications (6.88) was used in calculating the least significant difference between means.

*Experiments 1 and 2 (early-crop field).*—Seed potatoes certified to be low in leafroll content were planted between April 12 and 20. Irrigation drainage divided the field into small sections, and no section was large enough for all plot replications. Therefore the treatments were arranged in two experiments. In experiment 1 applications were made on May 13 and 28, June 8, and July 2, and in experiment 2 on May 19 and June 6, 17, and 29. The potatoes were harvested between September 3 and 16.

Significantly more green peach aphids were found in plots treated with sodium fluoaluminate than in those treated with any other dust (table 1). Six days after the last application there were 281 green peach aphids per 300 leaves and 23 days after the last application there were 6,361. The aphids increased most rapidly in the sodium fluoaluminate plots.

The two DDT-sulfur dusts gave good seasonal control of the green peach aphid. The toxic action persisted for a longer period than did that of DDT dusts without sulfur. The addition of 2 per cent of oil to

DDT dusts did not increase their effectiveness against the aphids.

Parathion dusts were highly effective against the green peach aphids and potato aphids present in the field at the time of application, but their toxicity dissipated more rapidly than did that of the DDT-sulfur dusts. Seven days after the last application of 0.5 per cent parathion dust there were 17 green peach aphids per 300 leaves and 35 days after the last application there were 1,098. The dust mixture containing sodium fluoaluminate and parathion also had little residual effect. Six days after the last application there were 18 green peach aphids per 300 leaves in these plots and 23 days after the last application there were 501. The dust mixture containing DDT and parathion was no more effective than the DDT dust in the early-crop field, although it was more effective than the 0.5 per cent parathion dust. The seasonal population peak occurred in experiment 1 on July 25, 23 days after the last application, and in experiment 2 on August 4, 35 days after the last application.

Potato aphid populations were comparatively low in all treatments. The DDT-sulfur dusts were not effective against this aphid, and approximately equal numbers were found in the plots treated with DDT-sulfur and in those treated with sodium fluoaluminate, where the greatest numbers of green peach aphids were found.

No distinct leafroll symptoms developed in the plants, and no phloroglucinol tests were made for leafroll. Few of the tubers taken from the plots at harvest time had net necrosis. Leafroll readings made June 20, 1950, on potato plants grown from tubers collected from the treated plots at harvest time in 1949 showed the greatest spread of leafroll in plots treated with sodium fluoaluminate (table 1).

*Experiment 3 (late-crop field).*—Seed potatoes certified to be low in leafroll content were planted between June 26 and 28. Dust applications were made on July 25, August 2 and 22, and September 2. The potatoes were harvested between October 20 and 29.

In the late-crop field several of the dusts that gave good control of the green peach aphid in the early-crop field were no more effective than the sodium fluoaluminate dust (table 2). The parathion dusts were relatively ineffective during the period of heavy migration of aphids into the field, although they were effective after the summer migration ceased. The dust containing parathion and DDT gave a very good seasonal control of wingless green peach aphids. Both of the dusts containing DDT plus oil were relatively ineffective.

The dusts containing DDT and sulfur gave the best control of winged green peach aphids. However, the 0.5 per cent parathion dusts, alone and with DDT, were just as effective against the wingless green peach aphids.

In this field the peak of aphid population occurred the last week in

TABLE 2.—*Effectiveness of various insecticide dusts in controlling aphids and preventing spread of leafroll on late-crop potatoes in 1949. Experiment 3.*

| Insecticide | Green Peach Aphids | | Potato Aphids | | Incidence of Leafroll | | |
|---|---|---|---|---|---|---|---|
| | Winged | Wingless | Winged | Wingless | Net Necrosis | Phloroglucinol Test | Plant Test in 1950 |
| | Number | Number | Number | Number | Per cent | Per cent | Per cent |
| DDT: | | | | | | | |
| 5 per cent | 1,257 | 12,590 | 13 | 135 | 16.8 | 25.0 | 49.0 |
| 5 per cent plus oil 2 per cent | 1,275 | 15,696 | 19 | 116 | 13.8 | 30.0 | 57.4 |
| 3 per cent plus oil 2 per cent | 1,211 | 13,467 | 14 | 124 | 14.5 | 29.2 | 52.3 |
| 4 per cent plus sulfur 80 per cent | 796 | 8,179 | 31 | 182 | 9.0 | 17.6 | 45.3 |
| 5 per cent plus sulfur 75 per cent | 630 | 5,957 | 16 | 134 | 7.5 | 10.7 | 43.1 |
| Sodium fluoaluminate: | | | | | | | |
| 33.3 per cent | 1,306 | 14,585 | 10 | 143 | 18.0 | 22.1 | 61.3 |
| 33.3 per cent plus parathion 0.5 per cent | 1,311 | 10,037 | 19 | 98 | 11.3 | 24.2 | 40.4 |
| Parathion: | | | | | | | |
| 0.5 per cent | 966 | 8,730 | 10 | 76 | 8.8 | 26.7 | 43.0 |
| 0.5 per cent plus DDT 5 per cent | 986 | 7,756 | 18 | 78 | 5.8 | 25.8 | 43.6 |
| 1 per cent | 1,358 | 10,610 | 18 | 83 | 10.0 | 25.0 | 41.3 |
| Difference required for significance (P=5 per cent) | 321 | 3,366 | 12 | [1] | 5.0 | 7.4 | 12.0 |

[1] Not significant by the *F* test.

July, when the first dust was applied. A second but much smaller peak occurred on October 10, 35 days after the last dusting.

As in experiments 1 and 2, the DDT-sulfur dusts did not control the potato aphid and populations were among the highest that followed any treatment.

The phloroglucinol test made in the fall after insecticide applications had ceased (September 21 to October 4) indicated that the plots dusted with DDT-sulfur had the fewest plants affected with leafroll. However, counts of plants with tuber-borne leafroll, made the following spring from tubers that had been collected from treated plots and replanted, showed that dusts containing parathion were also effective in preventing spread of leafroll .All plots except those dusted with DDT plus oil had significantly less leafroll than the ones treated with sodium fluoaluminate (table 2).

## DISCUSSION

Since very little leafroll was observed in plants grown from tubers taken from the early-crop field of Netted Gem potatoes, it is evident that there was little spread of leafroll by the spring-migrant forms of the green peach aphid. Although plants grown from tubers collected from the plots dusted with sodium fluoaluminate had a 23 per cent incidence of leafroll when examined on June 20, 1950, few of the tubers in the 1949 crop acquired net necrosis.

In the late-crop field, however, large numbers of winged summer-migrant forms of the green peach aphid attacked the plants as soon as they emerged from the ground about July 20. The aphid migration continued for 3 weeks. Most of the plants that showed leafroll symptoms in September probably became infected by these winged aphids.

Data presented in figure 1, *A*, show that the current-season leafroll in the late-crop field was generally greater in plots where the highest populations of aphids occurred during the early period of plant growth. However, the counts made on July 3, 1950, on plants grown from tubers collected in these plots (Figure 1, *B*) indicated that the leafroll infection had doubled from the time the phloroglucinol tests were made. Although many of the plants examined in September may have been infected, although symptomless, the increase in leafroll after these counts were made seems to be correlated with the late-fall increase of winged and wingless aphids, so that the total leafroll spread is closely related to the total seasonal aphid population.

Figure 1, *B, C*, shows the relationship between the amount of leafroll in the various treatments and the amount of net necrosis in tubers from corresponding treatments. The incidence of net necrosis is much lower than the incidence of leafroll in the plants. A correlation coefficient

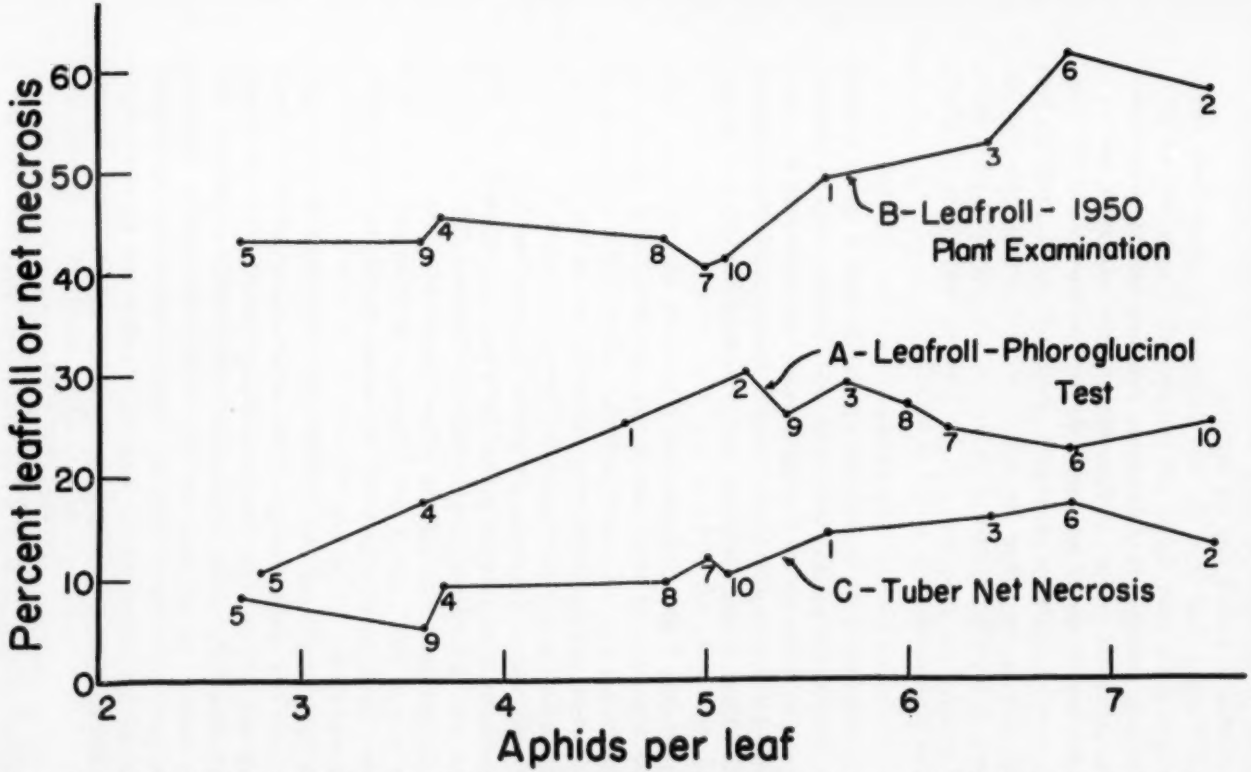


Figure 1.—Effect of aphid population on the spread of leafroll and the development of net necrosis. Numbers on the curves refer to insecticide treatments as follows; 1: 5 per cent DDT; 2: 5 per cent DDT plus 2 per cent oil; 3: 3 per cent DDT plus 2 per cent oil; 4: 4 per cent DDT plus 80 per cent sulfur; 5: 5 per cent DDT plus 75 per cent sulfur; 6: 33.3 per cent sodium fluoaluminate; 7: 33.3 per cent sodium fluoaluminate plus 0.5 per cent parathion; 8: 0.5 per cent parathion; 9: 0.5 per cent parathion plus 5 per cent DDT; 10: 1 per cent parathion. Values for current-season leafroll (*A*) are plotted against total green peach aphids per leaf in the first 4 counts. Curves *B* and *C* are plotted against total green peach aphids per leaf for the season (6 counts). *B* and *C* do not include values for missing plots.

($r = 0.649^{**}$), calculated by using the data from all plots, indicated a high correlation of leafroll and net necrosis.

The DDT-sulfur dust gave the best protection of plants from attack by the winged green peach aphid, and consequently from leafroll infection, during the early development of the plants. Parathion failed to give residual protection during the period of heavy winged-aphid migration, and, as a result, much leafroll spread apparently occurred in the plots at this time. After the summer migration of winged aphids had ceased, parathion was highly effective in controlling the aphids and fall populations built up more slowly in parathion-treated plots than in those receiving other treatments. Consequently, parathion and DDT-sulfur dusts were of nearly equal value in preventing the spread of leafroll.

## SUMMARY

Four applications of 10 insecticides were made with a power ground duster to Netted Gem potatoes planted for early and late crops at Yakima, Washington, to determine their relative values for controlling the green peach aphid (*Myzus persicae* (Sulz.)) and the potato aphid (*Macrosiphum solanifolii* (Ashm.)) and, indirectly, for preventing the spread of potato leafroll.

In experiments 1 and 2, on potatoes planted for an early crop, dusts containing 4 per cent of DDT and 80 per cent of sulfur, 5 per cent of DDT and 75 per cent of sulfur, or 5 per cent of DDT all gave good control of aphids and the incidence of leafroll did not exceed 5.8 per cent. Aphid populations were highest where 33.3 per cent of sodium fluoaluminate dust was used, and on those plots the leafroll incidence was 23 per cent.

In experiment 3, on potatoes planted for a late crop, the highest aphid population was again found in plots that had received 33.3 per cent of sodium fluoaluminate dust, and the leafroll incidence was 61.3 per cent. Five per cent of DDT, and 3 and 5 per cent of DDT with 2 per cent of oil were also relatively ineffective for aphid control, and the leafroll incidence was 49 to 57.4 per cent.

A dust containing 5 per cent of DDT and 75 per cent of sulfur gave the best control of aphids throughout the entire season, and the incidence of leafroll was 43.1 per cent. Dusts containing parathion were relatively ineffective during the period of extensive winged-aphid migration; consequently leafroll transmission was high during this period. However, parathion gave good control after the migration had abated and leafroll incidence did not exceed 43 per cent. DDT-sulfur and parathion dusts were equally effective in preventing the spread of leafroll.

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# NATURALLY OCCURRING STRAINS OF THE POTATO LEAF ROLL VIRUS

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Three distinct strains of the leaf roll virus have been found in certain areas of Wisconsin.[1] To determine whether these and other strains occur in other potato growing areas of the United States and Canada, a collection of isolates of the leaf roll virus was made and studied under controlled conditions in the greenhouse.

In addition to leaf roll infected potato tubers obtained from the commercial potato areas of Wisconsin, others were sent in by cooperators in Idaho, Louisiana, Maine, Minnesota, New York, Nebraska, North Dakota, South Dakota, Tennessee, Washington, Prince Edward Island, British Columbia, Ontario, and New Brunswick. Tubers from 56 sources were assembled and the plants grown from these tubers were held under cages in the greenhouse. Plants from each source of the virus were colonized with nonviruliferous aphids (*Myzus persicae* Sulz.) for three days, after which aphid transfers were made from each isolate source to the indicator plant, *Physalis floridana* Rydb. This plant was used as a test host because it was found in earlier studies to show signs of the disease 6 to 8 days after inoculation. In each transmission series, 5 plants were inoculated with each collection and each transfer was repeated three times for verification of symptoms. *Datura stramonium L.* var. *tatula* (L.) Torr. was used as a stock culture plant for all isolates. The use of this host eliminated the possible mixture with potato virus Y, since this plant is known to be immune from this virus.

Symptom development in *P. floridana* followed a rather consistent sequence but there were variations in type, severity, and longevity of symptoms caused by the leaf roll isolates from different sources. Symptoms consisted of leathery texture of the leaves, mild to severe leaf rolling, basal cupping and chlorosis, leaf and petiole epinasty, petiole twisting and general plant stunting. Repeated inoculation trials verified the consistency of symptoms incited by each isolate source.

The 30 leaf roll isolates collected in the potato areas of Wisconsin were classified into 3 strains on the basis of symptoms they produced on *P. floridana*. Strain 1 characterized by mild chlorosis, moderate rolling and basal cupping of the leaves, mild to moderate petiole epinasty without twisting, and mild plant stunting. Recovery from the initial shock caused by the virus was rapid, and subsequent growth was only slightly below

that of the control plants as shown in figure 1, D. Seven of 26 isolates from outside of Wisconsin were classified as strain 1. Strain 2 incited moderate chlorosis, rolling and basal cupping of the leaves, mild to moderate epinasty and twisting of the petioles, and moderate plant stunting. Recovery of the infected plants was fairly rapid, as shown in figure 1, C, but growth was somewhat less than that of plants inoculated with strain 1, figure 1, D. Six of the 26 isolates from outside of Wisconsin were placed in strain 2. Plants inoculated with strain 3 exhibited severe chlorosis, rolling and basal cupping of the leaves, epinasty and twisting of the petioles, and severe stunting of the plants. The plants recovered slowly from the initial effects of the virus and very little growth resulted. They remained severely stunted as shown in figure 1, B. Twelve of the 26 isolates from outside of Wisconsin were placed in strain 3. Strain 4, not reported from Wisconsin, was represented by only one isolate which was collected in the vicinity of Clark, South Dakota. Symptoms incited by this strain were characterized by very severe chlorosis, rolling and cupping of the leaves, severe petiole epinasty and twisting and very severe stunting of the plant. There was no recovery from the initial effects of the virus. About 16 to 18 days following inoculation with strain 4 at 24° C. leaves abscissed and the plants were dead a few days later (Fig. 1, A).

The 4 leaf roll strains were each transferred to a series of 5 young *P. floridana* plants infected with potato viruses $X^H$, $X^{RS}$, Y and A, respectively. In another inoculation series the combinations were duplicated except that the leaf roll inoculations were made 3 days before reinoculation with the other 4 viruses. No synergistic reaction resulted with the above virus combinations which showed that the presence of $X^H$, $X^{RS}$, Y or A viruses was not responsible for the wide symptom differences incited by the 4 type strains of the leaf roll virus.

In the course of these studies, it was noted that temperature as well as light intensity affected materially the time of expression and severity of symptoms produced on inoculated plants. A series of 50 *P. floridana* plants were preconditioned for 5 days at 16°, 20°, 24° and 28° C. Ten plants, at each temperature, were inoculated with each of the 4 virus strains to determine the optimum temperature for the development and expression of typical leaf roll symptoms. At 16° C., all plants grew slowly, the inoculated plants showing moderate symptoms about 14 days following inoculation. Symptoms were evident in 10 days with all 4 strains at 20° C. Plants infected with strains 1 and 2 recovered slowly and resumed growth almost comparable to that of the controls. Strain 4 severely stunted the plants and recovery was slow (Fig. 2, C). The first evidence of infection with all 4 strains appeared 6 to 8 days after inoculation at 24° C. Plants infected with strains 1, 2 and 3 recovered from the initial inoculation

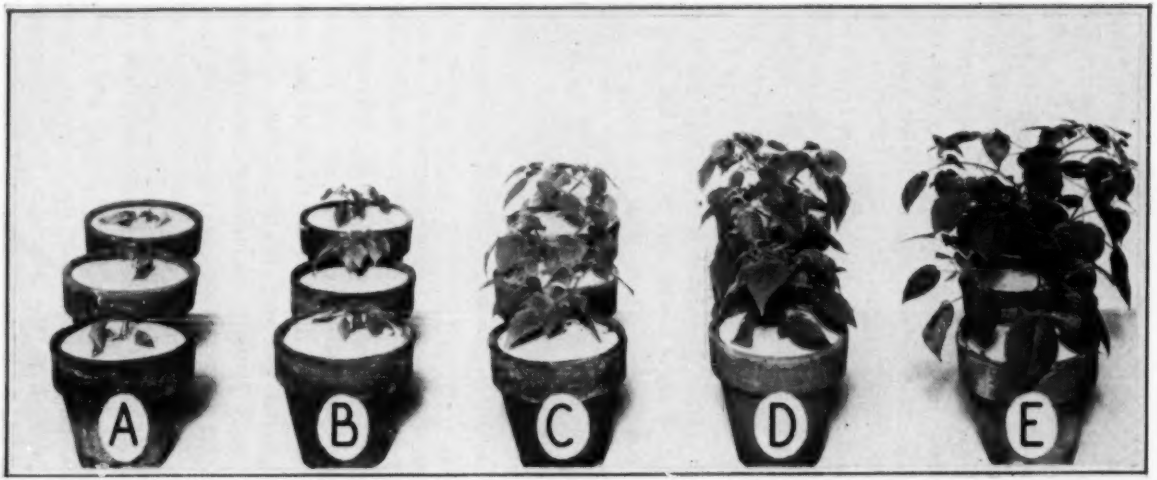


Fig. 1.—Representative *Physalis floridana* plants 25 days after inoculation at 24° C. showing range of symptoms for establishing bases of strains. A, strain 4; B, strain 3; C, strain 2; D, strain 1; E, uninoculated controls.

effects and resumed growth typical of each strain. On the other hand, plants inoculated with strain 4 failed to recover, defoliated rapidly and were morbid after 20 days. At 28° C., symptoms were also evident in 6 to 8 days but recovery of plants infected with strains 1, 2 and 3 was much more rapid than at 24° C. Symptom development in plants inoculated with strain 4 was comparable to those at 24° C. (Fig. 2, C).

A series of 25 *P. floridana* plants were preconditioned for a period of 3 days in the greenhouse under controlled day lengths of 8, 12 and 16 hours after which each of the 4 strains was transferred to each of 5 plants under the above light conditions .Symptoms were evident with all 4 strains in 7 days at 16-hour day length, whereas symptom expression was delayed 3 days at day lengths of 8 and 12 hours. The symptoms produced by each strain under each day length were typical of those incited by the respective strains after 6 to 8 days under ordinary daylight. Limited evidence indicates that the factor of light intensity is more important than day length in symptom expression. Additional light intensity studies are under way.

In plants of *P. floridana* inoculated with each of the 4 strains of the leaf roll virus at 1, 2, 3 and 4 weeks after the first leaf stage the symptom pattern remained comparable. There was, however, a 3-day delay in symptom development in the older plants. Although strain differences were very evident in older inoculated plants, recovery and resumption of growth were much more rapid, especially with strains 1 and 2.

Various hosts were tested for susceptibility to infection and response to the four leaf roll strains. *Nicotiana tabacum* L. var. Havana 38, *N. rustica* L., *N. glutinosa* L., *Datura stramonium* L. var. *tatula* (L.) Torr., *D. aegyptica* L., *D. fastuosa* L., and *Physalis angulata* L. were found to be susceptible, and the virus was recovered in *P. floridana* by means of aphids. Members of the genus *Datura* are more readily infected, yet tolerant to the virus, than any host tested. Symptoms on the 3 *Nicotiana* species consisted of slight stiffness of the older leaves. *P. angulata* was somewhat resistant to infection but was very readily infected. None of the hosts was as satisfactory as *P. floridana* as indicator plants for the presence of the virus or for strain differentiation.

## SUMMARY

Results of these studies of isolates of the potato leaf roll virus from 56 various seed potato areas of the United States and Canada, covering a wide geographical range, substantiate the existence of distinct strains of the virus. In addition to the 3 strains from Wisconsin previously reported, one additional very severe strain, designated as strain 4, exists in at least one area in South Dakota. The strains are distinguished most readily by the initial symptom type and relative disease severity on

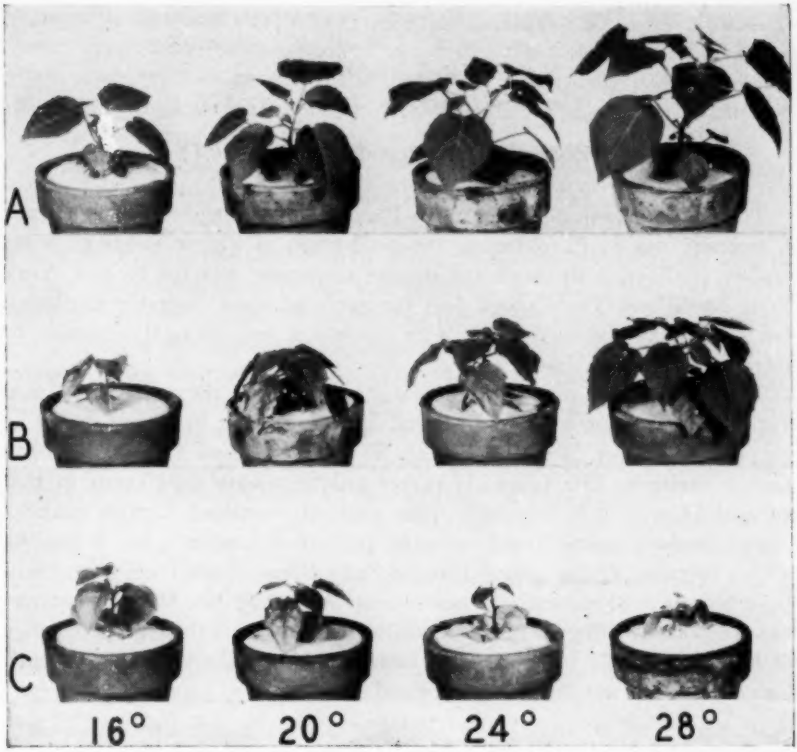


Fig. 2.—The effect of temperature on symptom expression 15 days after inoculation of *Physalis floridana*: A, uninoculated controls, left to right at 16°, 20°, 24° and 28° C.; B, strain 2 at the same temperatures; C, strain 4 at the same temperatures.

*P. floridana*. The response of *P. floridana* infected with strain 4 at 24° and 28° C., is directly opposite to that of the other 3 strains at the same temperatures.

The four strains produced a wide range of symptoms on *P. floridana*, varying from severe defoliation and death of plants with strain 4, to moderate initial symptoms and subsequently rapid recovery with strain 1.

A temperature of 24° C. was found to be optimum for symptom expression and development. Distinct strain differences, however, are shown at 16° and 28° C.

Strains 1, 2 and 3 seem to be coexistent in most potato growing areas of the United States and Canada.

Further experiments are being conducted to study the 4 leaf roll strains under controlled conditions on a number of potato varieties.

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# THE CANOGA POTATO[1]

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The potato breeding project in the Plant Breeding Department at Cornell University has as its objective the production of higher yielding, better quality potatoes, with insect and disease resistance, adapted to New York State conditions. The Canoga does not carry all these desirable attributes, but because of the qualities it does possess it was thought advisable to introduce it at this time.

The surest way, and the quickest, to determine the value of a new variety is to release it to the growers. If the new sort has merit it will be propagated; if not, it will disappear. There need be no fear of too many named varieties. The potato is rather unique among field crops in that varietal adaptation is frequently quite narrowly localized. Certain qualities are particularly prized in a given area, perhaps limited to a few farms. As a case in point, at the annual Empire State Potato Club Field Day, there have been several requests for new stocks of seedling No. 866. The answer has been that seedling No. 866 was discarded because of the high percentage of leafroll. "That's too bad," one farmer said, "I don't care how much leafroll it had, it was the best quality and finest flavored potato I ever grew."

In his search for the perfect potato it may be that the breeder has been emphasizing the wrong things. It was reported in a recent issue of the Saturday Evening Post, that Mr. David Burpee, who developed the magnificent, showy bloom in the sweet pea, has more recently discovered that many persons enjoy the delightful fragrance of the old-fashioned sweet pea. The rose breeders, sooner or later, will make the same discovery concerning rose fragrance. It might well be that the potato breeder has already sacrificed too much in culinary quality and flavor in order to produce a high yielding, disease free, smooth, white skinned tuber with eye appeal.

It was thought that the Canoga was field resistant to leafroll. For six years prior to its release in 1950 only a trace of leafroll was recorded. However, last year a fairly high percentage of the plants were classified as virus leafroll. Nevertheless, at no time have any tubers of this variety shown any symptoms of net necrosis or any other internal discoloration.

The Canoga tuber is thick, square-round, with creamy skin. The flesh is white, mealy when baked, and does not slough when boiled. Preliminary tests indicate it is a good chipper. The cooked tubers have an exceptionally fine flavor and usually stay white.

Under the extremely adverse growing conditions of the 1949 season at Ithaca, when many varieties broke down badly, the Canoga maintained its typical shape with no growth-cracks, knobs, or abnormally large potatoes. The plant is resistant to leafhoppers and tarnished plant bugs. It matures about ten days later than Katahdin.

At Ithaca the Canoga has proved to be quite heavy yielding. The most extensive test of this variety was one conducted by Dr. A. J. Pratt. In a well designed experiment, repeated in several counties in New York State, there were eight varieties compared under three sets of conditions, irrigation and no irrigation, early and late planting, and mulch and no mulch. It is rather generally conceded that among the named varieties now available to the growers the Kennebec and Essex are the best in yield. In table 1 the figures represent the calculated acre yields of Canoga, Kennebec, and Essex. In addition, the specific gravity of each lot was determined by Dr. Pratt, and those figures are given in the second part of table 1. These data are from the 1949 tests. The 1950 data from a similar experiment were not available at the time of this writing.

TABLE 1.—*Yield and specific gravity of three varieties, 1949*

*(Yields in bushels an acre of U. S. No. 1 potatoes)*

*(County where grown)*

| Variety | Allegany | Chenango | Genesee | Washington | Wayne | Average |
|---|---|---|---|---|---|---|
| Kennebec | 325† | 794 | 337 | 343 | 531 | 466* |
| Canoga | 309 | 738 | 242 | 245 | 592 | 425 |
| Essex | 297 | 672 | 239 | 197 | 521 | 385 |
| Specific gravity of the same lots as in yield table | | | | | | |
| Kennebec | 1.076 | 1.074 | 1.067 | 1.069 | 1.064 | 1.070§ |
| Canoga | 1.081 | 1.074 | 1.069 | 1.071 | 1.066 | 1.072 |
| Essex | 1.069 | 1.063 | 1.059 | 1.066 | 1.058 | 1.063 |
| Highest of 8 varieties | 1.082 | 1.07[illegible] | 1.069 | 1.071 | 1.067 | |

†These figures are averages of 16 plots of each variety, in each county.

*A difference of at least 56 bushels an acre, is necessary, between any two of these five-county variety averages that the probability against its occurrence being due to chance shall be .95.

§A difference of at least .0036 units, is necessary, between any two of these five-county variety averages that the probability against its occurrence being due to chance shall be .95.

The Canoga was produced by the author at the breeding plot in Gabriels, Franklin County. A seedling from a cross made in 1938 between Albion and Katahdin was pollinated by Katahdin in 1940. From that progeny, after adequate testing, the seedling No. 2V2452 was found to be superior and it was named Canoga.

## DESCRIPTION

Plants medium in size and spreading; stems medium in thickness, slightly angled; nodes slightly swollen, green; internodes green; wings straight, green; stipules medium in size, green, scant pubescence; leaves medium in length, medium width, open to medium type, medium green; midribs green, no pubescence; primary leaflets narrowly ovate, medium in size, three to four pairs; ratio width to length .59 mm., petioles green; secondary leaflets medium in number, between pairs of primary leaflets; and tertiary leaflets few.

Inflorescence moderately branched, leafy bracts, few; peduncles medium in length, green, pubescence scant; pedicels medium long, green, pubescence scant; flowers, calyx lobes medium in length, green, pubescence scant; corolla medium in size, white; anthers lemon-yellow; pollen moderately abundant, fair quality; styles straight; stigmas globose, not lobed, green.

Tubers are round, medium in thickness; a random sample of 100 were found to be 74.4 mm in width, 75.7 mm in length, and 54.8 mm in thickness; the ratio of width to length was .982, the ratio of thickness to width was .737; skin flaked, cream, self-colored; eyes shallow, cream; eyebrows medium, slightly curved, inconspicuous; flesh white; sprouts slight flush pink at base; maturity medium late.

[1] Paper No. 270, Department of Plant Breeding, Cornell University, Ithaca, New York.

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